Today’s Topics

- Introduction
- Computer Vision
  - Feature-based registration
  - Automatic image registration
  - Object recognition/Rotation correction with SURF and RANSAC
  - Face detection with Viola-Jones
  - Histogram-based tracking with CAMShift
  - Stereo image rectification
- Video processing
- Summary
Computer Vision

Using images and video to detect, classify, and track objects or events in order to “understand” a real-world scene

Image Processing
- Remove noise
- Adjust contrast
- Measure
  …

Computer Vision
- Detect
- Identify
- Classify
- Recognize
- Track
  …

Interpretation
- Pedestrian
- Bicyclist
- Truck
- Car
- Traffic violation
- Accident
  …
Examples of Computer Vision with MATLAB
Typical Computer Vision Challenges

- Variable lighting conditions
- Unknown scene depth or perspective
- Background clutter
- Partially hidden objects (occlusion)
- Differences in scale, location, and orientation
Technical Computing with MATLAB

Access
- Files
- Software
  - Code and Applications
- Hardware

Explore and Discover
- Data Analysis and Modeling
  - For k=1:max
  - \( x = \text{fft}(\text{data}) \)
  - \( y = 20 \times \text{log10}(y) \)
- Algorithm Development
  - Application Development
  - Option 1
  - Option 2

Share
- Reporting and Documentation
  - PDF
  - .doc
  - .html
- Outputs for Design
- Deployment
  - MATLAB
  - Excel
  - .NET
  - .exe
  - C/C++
  - Java
  - .dll
Key Products for Computer Vision

- Computer Vision System Toolbox - NEW
- Image Processing Toolbox
- MATLAB
- Statistics Toolbox
Computer Vision System Toolbox

Design and simulate computer vision and video processing systems

- Feature detection
- Feature extraction and matching
- Feature-based registration
- Stereo vision
- Video processing
- Motion estimation and tracking
- Video file I/O, display, and graphics
Features are Critical to Computer Vision

- Edge
- Corner
- Template
- SURF
- MSER
Feature-Based Registration

- Workflow
  - Feature detection
  - Feature extraction
  - Feature matching
  - Geometric transformation estimation with RANSAC
RANSAC

- Random Sample Consensus
  - Iterative estimation of parameters to a mathematical model from a set of observed data that contains outliers

- Our uses of RANSAC
  - Estimate Geometric Transformation
  - Estimate Fundamental Matrix (useful for stereo vision)
Rotation Correction with SURF

- **Workflow**
  - SURF Feature detection
  - SURF Descriptor extraction
  - Feature matching
  - Geometric transformation estimation with RANSAC
Object Recognition with Features

Workflow
- Use SURF features to represent object
- Detect features in video
- Match features from two sources
- Use RANSAC to estimate object location
Viola-Jones Face Detection

Algorithm details
- Haar wavelet features using integral image
- Adaboost classifier for feature selection
- Cascading of classifiers to quickly weed out negative candidates
- Use several modes together to overcome false positives
Histogram-based Tracking

**Workflow**
- Detect face and nose – get ROI
- Use Hue channel from HSV space
- Initialize histogram tracker
- Reacquire face if track lost
Stereo Image Rectification
Recovering Scene Depth with Stereo Cameras
Epipolar Geometry
Fundamental Matrix

\[ X_L^T F X_R = 0 \]
Video Processing

- Video file I/O and display
- Video pre-processing
- Motion estimation and analysis
Motion Estimation and Analysis

- Techniques
  - Block matching
  - Optical flow
  - Template matching
  - Background estimation using Gaussian mixture models

- Applications
  - Object tracking
  - Interpolation
  - Compression
## Typical Parts of a Computer Vision Algorithm

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Review: Key Products for Computer Vision with MATLAB

- Computer Vision System Toolbox
- Image Processing Toolbox
- Image Acquisition Toolbox
- Statistics Toolbox
Statistics Toolbox

Perform statistical analysis, modeling, and algorithm development

- **Clustering**
  - Principle components analysis
  - K-means
  - Gaussian mixture models

- **Classification**
  - Naïve Bayes
  - K-nearest neighbor search
  - Boosted decision trees
    - AdaBoost, GentleBoost, LogitBoost,…
Why Use MATLAB for Computer Vision?

- Comprehensive environment
  - Analysis, algorithm development, visualization, etc.
- Broad library of algorithms
  - Computer vision
  - Image processing
  - Classification and clustering
- Documentation, examples, and technical support
- Increased productivity over C/C++ programming
For More Information

- [mathworks.com/products/computer-vision](http://mathworks.com/products/computer-vision)
- Relevant demos:
  - Barcode Recognition
  - Image Rectification
  - Traffic Warning Sign Recognition
  - People Tracking
  - Video Mosaicking
- Documentation
- Contact your sales representative
Questions and Answers